Hybrid cycling in spinal cord injury

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Chapter 8

Epilogue

The main aim of this thesis was to evaluate the integrated effects of hybrid cycling versus handcycling on fitness, physical activity and health in physically inactive people with long-term spinal cord injury (SCI). To achieve this goal, a 16-week randomized controlled trial (RCT) was conducted in two Dutch rehabilitation centers with a specialized SCI unit. During 16 weeks, both the experimental (hybrid cycle) and control (handcycle) group trained twice a week for 18–30 minutes at an intensity of 65–75% of their heart rate reserve and/or a score of 4–7 on a 10-point rating of perceived exertion scale. Outcome measures were obtained in the week before the training program, after 8 weeks of training, and in the week after the training program. Parallel to this multicenter RCT, two cross-sectional studies were performed to (1) examine the metabolic and cardiorespiratory response during hybrid cycling versus handcycling at equal subjective exercise intensity levels, and (2) assess the reliability of a standardized method to measure proximal tibia and distal femur bone mineral density (BMD) using dual-energy X-ray absorptiometry. In the current chapter, the main findings of these studies are summarized and discussed in relation to the existing literature. Furthermore, implications for clinical practice and recommendations for future research are provided.

Effects of hybrid cycling versus handcycling on fitness, physical activity and health

In chapters 4, 5 and 7, the effects of the current 16-week RCT on fitness, physical activity and the health-related parameters cardiovascular disease risk factors, lower-body soft tissue composition, proximal tibia and distal femur BMD, and bone turnover markers are presented. The most important findings of these chapters were that (1) following 16 weeks of twice-weekly exercise, both the hybrid cycle and handcycle group showed positive effects on aspects of fitness, physical activity, cardiovascular disease risk factors and lower-body soft tissue composition, and (2) these positive effects over time were not significantly different between the two training groups (except for lean mass of the legs), indicating that for the outcome measures studied there were no additional benefits of the functional electrical stimulation (FES)-induced leg exercise over handcycling alone. Below, these findings are extensively discussed.

Fitness and physical activity

In chapter 3, it was demonstrated that hybrid cycling induces higher metabolic and cardiorespiratory responses than handcycling when exercising at equal subjective exercise intensity levels. Previous studies also found higher metabolic rates during hybrid exercise versus arm exercise alone and stated that this was caused by the larger active muscle mass during hybrid exercise.[80,132,133] However, in these studies, power output was used to standardize the exercise intensity and it remained unclear how the participants subjectively experienced the exercise intensity. It might be possible that the higher metabolic rates in these studies also coincided with higher rating of perceived exertion levels. Chapter 3 demonstrated that the higher metabolic and cardiorespiratory responses during hybrid cycling were achieved while 'feeling the same' as during handcycling. Based on these findings, it was hypothesized that hybrid cycling was more suitable for increasing cardiorespiratory fitness in people with long-term SCI than handcycling.

However, as described in chapter 4, no significant difference over time between the hybrid cycle and handcycle training group was found for fitness. A possible explanation for this finding is provided in the section on 'Training protocol'. In chapter 4 it was also demonstrated that the wheelchair-specific fitness (wheelchair exercise capacity, expressed as peak power output (PO_{peak}) and peak oxygen consumption (VO_{2peak})) was not significantly improved following the 16-week training program, while the cardiorespiratory fitness (expressed as resting heart rate) and the subjectively experienced fitness were. In the current RCT, exercise capacity was determined during an incremental test in a manual wheelchair since, in daily life, many people with SCI are dependent on such a wheelchair for mobility[129] and were therefore expected to benefit from an increased wheelchair-specific fitness. Moreover, previous studies have already demonstrated that both hybrid cycle[23,73] and handcycle[153] exercise can lead to improvements in PO_{peak} and VO_{2peak} if these outcome measures are assessed during a specific exercise test (i.e. hybrid cycle or handcycle test, respectively). However, in the current trial, PO_{peak} and VO_{2peak} were not significantly increased following 16 weeks of training, suggesting that hybrid cycling and handcycling may not be the best exercise modes to improve wheelchair-specific fitness and that it might be better to train more specifically (i.e. wheelchair training). That said, ~40% and ~65% of the participants in this study showed non-significant improvements in PO_{peak} and VO_{2peak}, respectively, indicating that the training program certainly beneficially influenced these fitness measures in a considerable part of the participant group. Moreover, the significant overall improvement in resting heart rate and subjectively experienced fitness also indicate beneficial effects of hybrid cycle and handcycle training on fitness.

Although there was no beneficial effect on objectively measured wheelchair activity following the 16-week RCT, the overall increased score on the Physical Activity Scale for Individuals with Physical Disabilities suggests an improved physical activity level (chapter 4). Moreover, many participants in our study indicated that several activities of daily living (e.g. transfers, transportation and housework) became easier due to the subjectively experienced improved fitness as a consequence of the training program. The above-described findings regarding fitness and physical activity are supported by Nooijen et al.,[121] who showed that increased physical activity levels are associated with increased fitness levels in people with SCI.

Cardiovascular disease risk factors

In chapter 5 it was demonstrated that both the 16-week hybrid cycle and handcycle exercise program led to improvements in several cardiovascular disease risk factors, including several metabolic syndrome components (waist circumference, diastolic blood pressure and insulin sensitivity), inflammatory status (C-reactive protein, interleukin (IL)-6 and IL-6/IL-10 ratio) and visceral adiposity (trunk and android fat percentage). In contrast to trunk and android fat mass, the overall fat percentage of these regions, as well as the overall waist circumference (a reliable surrogate of visceral adiposity in able-bodied people)[106] significantly decreased, suggesting that both hybrid cycle and handcycle exercise have the potential to reduce visceral fat and improve body composition in people with long-term SCI. This finding was in accordance with a study by Gorgey et al.,[66] who found a reduced visceral adiposity after 12 weeks of twice-weekly FES-induced leg training in people with SCI. Furthermore, the significant overall improvement in insulin sensitivity was supported by several other studies on the influence of exercise on insulin sensitivity in people with SCI.[48,90,112] Finally, the overall improved inflammatory status was consistent with the findings of Griffin et al.,[68] who reported a significant reduction in resting IL-6 and C-reactive protein following a 10-week FES-induced leg cycle training program. In contrast to the above-described positive effects of exercise, no significant training effects were found for the lipids triglycerides and high-density lipoprotein cholesterol. In a systematic review by Carlson et al.,[26] it was concluded that there is yet insufficient evidence that exercise alone improves lipid disorders in people with SCI, and that it requires further investigation to examine whether a combined exercise and dietary intervention is the optimal method for improving the lipid spectrum in this population.

Lower-body soft tissue composition and bone mineral density

Of all outcome measures analyzed in this thesis, the only significant difference over time between the two training groups was found for lean mass of the legs; an increase was found in the hybrid cycle group, while a decrease was observed in the handcycle group (chapter 7). In contrast to the unexpected decrease in lean mass in the handcycle group, the increase in lean mass as a consequence of the FES-induced leg exercise in the hybrid cycle group is supported by the literature.[11] Since muscle atrophy of the lower limbs is an important risk factor for developing pressure ulcers (a common secondary complication in SCI),[96] improving the lower-body musculature by hybrid cycling might be a way to reduce the risk of pressure sores. Since fat mass of the legs equally decreased in both groups, it seems that hybrid cycling has no additional beneficial effect on lower-body adiposity over handcycling alone, suggesting that fat loss is a systemic effect of exercise.

In chapter 7 it was also shown that for both groups, proximal tibia and distal femur BMD, assessed with the in chapter 6 described reliable scan and analysis protocol, did not significantly change over time. In the literature, there is inconsistency regarding the effectiveness of FES-induced leg exercise on proximal tibia and distal femur BMD in people with long-term SCI; some studies found positive training effects,[14,29] while others did not.[e.g.138] It seems that the studies that found improvements in proximal tibia and/or distal femur BMD are those with a longer training period (i.e. 12 months), higher training frequency (i.e. five times a week), or higher power output of the legs.[15] In addition to the BMD measurements, the bone turnover markers procollagen type 1 amino-terminal propeptide (P1NP) and cross-linked C-telopeptide (CTX) were determined in blood. The fairly small alterations observed in these bone turnover markers following the 16-week training program, including the significant reduction in P1NP, cannot be considered as clinically relevant. This finding was supported by data from Astorino et al.[4] who found that neither P1NP nor CTX levels were changed as a consequence of 6 months of exercise in people with SCI.

Other outcome measures and long-term training effects

As presented in chapter 2, besides the outcome measures analyzed in this thesis, numerous other outcome measures were obtained in the current RCT (e.g. vascular structure and function, quality of life, participation and immune function). Moreover, to examine the long-term training effects, most outcome measures were also obtained 26 weeks after the end of the exercise intervention. The other outcome measures obtained in this RCT as well as the 26-week follow-up data have not been evaluated yet. For some of the other outcome measures, it is assumable that hybrid cycling would induce greater benefits than handcycling alone. For example, based on previous studies on hybrid cycling,[147,148] it was hypothesized that the vascular structure (wall thickness and diameter) in the legs would improve in the hybrid cycle group, while it would remain unchanged in the handcycle group. Furthermore, it was hypothesized that possible beneficial effects of the 16-week exercise intervention could only be preserved on the long-term if the participants stayed physically active after the intervention. In the coming years, all the other outcome measures obtained in this RCT as well as the long-term training effects are intended to be analyzed and published by researchers of the Dutch clinical SCI rehabilitation network (www.scionn.nl).

Randomized controlled trials in SCI research

There is a strong demand for clinical trials to determine the effectiveness of interventions on different health problems (e.g. deconditioning, cardiovascular disease risk and osteoporosis) in people with long-term SCI. The focus of these trials should be on the underlying mechanisms responsible for adaptations to training in this vulnerable population, and a relatively long training period may be needed to detect substantial training effects.[15,117] Since the RCT is considered as the gold standard for a clinical trial, in the current thesis, the effects of hybrid cycle versus handcycle exercise on fitness, physical activity and health were investigated in a 16-week RCT. However, in practice, carrying out this RCT turned out to be fairly difficult.

Beforehand, it was expected that it would not be easy to recruit the intended number of 40 participants for the trial. To increase our chances, we chose to conduct the RCT in two rehabilitation centers with a specialized SCI unit in different parts of the Netherlands. Potential participants were selected from the databases of these centers following strict inclusion criteria. Initially, 313 individuals were assessed for eligibility, of which eventually 36 persons were randomly assigned to one of the two intervention groups. The two most important reasons why people were excluded from trial participation were: (1) they did not meet the strict eligibility criteria of the study, and (2) they were not able or willing to participate since the training program was too time-consuming for them. Because of the problems with enrolling participants, after one year, a slight adaptation to the inclusion criteria was deemed necessary; the time since injury was reduced from 10 to 8 years and the age at onset of the SCI was reduced from 18 to 16 years. Thanks to these adjustments, eventually three more participants were enrolled.

Besides the difficulty of including a sufficient number of participants, it was hard to keep the participants in the training program. Of the 36 participants, who were recruited over a period of two years, 16 individuals dropped out immediately after allocation to the training group or during the experimental trial. Reasons for drop out were illness and lack of adherence to the training. Despite the thorough medical screening preceding inclusion and the relatively good health status of the participants (as discussed in chapter 4 and 5), almost 50% of the drop outs had to stop due to health problems not related to the training program (e.g. pressure ulcers, bowel problems and kidney stones), indicating that people with long-term SCI are vulnerable for illness, and that interventions aiming to promote health are important in this population. The people who dropped out due to lack of adherence to the training indicated that the program was too time-consuming for them. However, since no baseline differences were observed for any of the outcome measures or personal and lesion characteristics between the group that dropped out and the group that completed the training program, it is not expected that the relatively high drop-out rate (44%) would have affected the findings of this study. Nevertheless, the large number of drop outs, as well as the difficulty to recruit a sufficient number of participants, questions the feasibility of the current RCT.

Therefore, future studies should consider how to make clinical trials more feasible and attractive for people with long-term SCI. First, for each future clinical trial in people with SCI, it should be carefully considered whether the RCT is definitely the most suitable experimental design to examine treatment effects. As a matter of fact, clinical researchers are increasingly addressing questions for which the RCT may not be feasible, practical or ethical.[7,171] In case RCTs cannot be easily implemented in settings or with participants of interest, West et al.[171] suggest to use a strong alternative experimental design (e.g. a randomized encouragement design or observational study) instead of changing the treatment or study population so that an RCT may be implemented. Thus, using alternative research designs might improve the feasibility of clinical trials in people with SCI. Furthermore, better facilitation of the training equipment might be a way to make these trials more feasible; for example, if people have the possibility to exercise at home, they do not have to come to a rehabilitation center for each training session, which saves considerable travel time and effort. However, since in total there were only three hybrid cycles available in the rehabilitation centers and there was no money available to buy more cycles, it was impossible to facilitate all participants. For the handcycle group, this would have been easier since more handcycles were available in the rehabilitation centers and most participants had their own handcycle. In that case, participants should only have been provided with an ergotrainer, which is relatively affordable. Besides the difficulty of facilitating the training equipment, exercising at home might bring along some additional problems. For instance, if people are instructed to train alone, it is more difficult for the researcher to control whether all participants correctly perform the exercise protocol. Furthermore, many people in the hybrid cycle group would need help with properly attaching the electrodes over the muscle groups, making transfers from their wheelchair to the hybrid cycle and vice versa, positioning the legs in the foot pedals, and controlling the electrical stimulation. Considering the above-mentioned issues regarding exercising at home, in the current RCT, it was chosen to train the participants in the rehabilitation center. In this way, trainers were able to properly standardize the training protocol and help participants throughout the exercise sessions. Finally, offering the opportunity to exercise in the evenings and weekends might be another way to make these interventions more feasible for people with long-term SCI. This would especially be ideal for people with a full-time job who want to participate but are not able to train during office hours.

The graded exercise test

To be able to compare the effects on fitness with the other two ALLRISC intervention studies (described in chapter 1), exercise capacity was assessed during a graded exercise test in a manual wheelchair on a motor-driven treadmill.[38] In the other ALLRISC exercise intervention study, a 16-week low-intensity wheelchair exercise program was performed[159]; thus, exercise testing was specific to the training sessions in that study. However, this was not the case in the current RCT where a hybrid cycle or handcycle training program was performed.

At the start of this study, it has been considered to also include an incremental exercise test in the specific training set-up (either a hybrid cycle or handcycle) to examine potential positive effects on fitness. Valent et al.[154] described a standardized protocol to measure peak exercise capacity during a discontinuous graded peak exercise test in the handcycle on a motor-driven treadmill. However, in the literature there is a lack of good standardized hybrid cycle exercise testing protocols. In one study, an ergotrainer (Tacx, Technische Industrie Tacx B.V., Wassenaar, the Netherlands) was used to increase the workload every minute with steps of 10 Watt, and after 10 minutes with 20 Watt.[73] We have extensively tested this protocol with our own Tacx ergotrainers and concluded that it was not possible to gradually increase the power output with this device. We have also tried to perform a hybrid cycle exercise test on the treadmill, following the handcycle protocol of Valent et al.[154] However, the main problem with hybrid cycling on a treadmill was that when the electrical stimulation was increased, the cycle speed became higher than the speed of the treadmill belt (which was kept constant during testing), sometimes resulting in risky situations where the front wheel of the hybrid cycle hit the front of the treadmill.

Besides the difficulty of performing a well-standardized hybrid cycle incremental test, another, more ethical reason for not including an additional exercise test was that we did not want to overload the participants with measurements. The people participating in the current RCT already had to come to the rehabilitation center for 36 times (32 training sessions and four measurement days) and to the hospital twice (for vascular or BMD measurements). Since two different incremental exercise tests have to be performed on separate days, with at least 72 hours of relative rest in between the tests to provide sufficient recovery time, a second exercise test would have meant that the participants had to come to the rehabilitation center another four times and that the total duration of the RCT was increased with about two weeks.

The training protocol

In the current RCT, an interval training protocol (exercise blocks alternated with absolute rest) was used since previous studies suggested that these protocols are very convenient to prevent early muscle fatigue and soreness during training.[25,150] Furthermore, this type of protocol was expected to allow more people with a tetraplegia to complete the training program. During the 16-week training period, total cycle time was gradually increased from 18 to 32 minutes and resting time between the exercise blocks was decreased from 2 to 1 minute(s). Each session consisted of a short warm-up and cool-down period, including handcycling only. In practice, this training protocol turned out to be very suitable since all participants were able to complete all the training sessions. Besides temporary muscle soreness due to exercise, no serious adverse events (e.g. serious musculoskeletal complaints) were reported as a consequence of the 16-week training program. Occasionally, participants indicated that the muscle soreness (mostly occurring in the shoulders) was a limiting factor during training. In these cases, slight adjustments to the protocol were made (e.g. increasing the resting time between the exercise blocks) to be able to complete the total cycle time of that training session. Sometimes, an extra resting day was advised by the trainer to allow the participant to fully recover from the training session.

The current training program was largely based on the American College of Sports Medicine's guidelines for aerobic training programs in people with disabilities (i.e. frequency: 3 × 30 minutes, duration: 8–12 weeks, intensity: 70% heart rate reserve).[2] Initially, the intention was to train three times a week, following these guidelines; however, to increase the chance of including a sufficient number of participants and decrease the chance of drop outs and non-compliance, a training frequency of two times a week was considered to be more feasible in this physically inactive population with long-term SCI. In hindsight, considering the difficulties with the inclusion and the high drop-out rate in the current RCT, we believe this was a good choice. Based on previous studies,[23,73,147,148] a training period of 16 weeks was considered to be sufficient to detect substantial effects on fitness, physical activity and health. However, for some outcome measures (e.g. proximal tibia and distal femur BMD),[15] a longer training period might have been necessary to find significant and clinically relevant changes. Nevertheless, similar to a higher training frequency, a longer period of training might have resulted in even more difficulties with inclusion and a higher drop-out rate and non-compliance.[40,76]

To ensure that the imposed exercise intensity of 65–75% heart rate reserve was maintained throughout the exercise program, heart rate was continuously monitored during training. Rating of perceived exertion, serving as a supplementary measure of exercise intensity, had to be 4–7 on a 10-point scale[120] and was assessed after each exercise block. All participants were very well capable to train at the target exercise intensity during the program, and to control the intensity by making adjustments in cycle speed and gear setting. As described in chapter 2, the heart rate reserve calculation was based on the incremental exercise test in the wheelchair. During the first training session, the calculated heart rate range was used to impose the exercise intensity. However, in practice it sometimes appeared that this range did not match the imposed rating of perceived exertion; mostly, an underestimation was made. In these cases, the heart rate range was adjusted to the participant's subjectively experienced exercise intensity. Beforehand, we knew this could occur in people with tetraplegia,[154] however, it also happened in those with paraplegia. A logical explanation for this is the fact that a wheelchair exercise test was used to calculate the heart rate range; during wheelchair propulsion, often lower peak physiological exercise responses (e.g. heart rate and oxygen consumption) are achieved than during hybrid cycling or handcycling.[39] Therefore, specific exercise testing might have been better to properly set the objective training intensity. In the preceding section on 'The graded exercise test', it is explained why we chose not to include an graded exercise test in the specific training set-up next to the graded wheelchair exercise test. Besides heart rate and rating of perceived exertion, other indicators to monitor exercise intensity during hybrid cycling and handcycling could have been used, such as power output. Since the use of heart rate as an indicator of training intensity can be unreliable in people with tetraplegia,[154] exercising at a certain percentage of peak power output might have been more suitable than exercising at a certain percentage of heart rate reserve in this population. However, at the start of the current RCT, there were no valid and reliable power meters (such as the SRM system (Schoberer Rad Messtechnik, Jülich, Welldorf, Germany)) available in both rehabilitation centers. Moreover, as for heart rate, in case of using power output as an indicator of training intensity, specific exercise testing should have been performed to prevent under- or overestimation of peak power output.

The people who were assigned to the hybrid cycle group immediately started with the 16-week hybrid cycle exercise protocol. However, a problem was that the lower-limb muscles of these people were relatively untrained at the beginning of the training program, often resulting in rapid lower-limb muscle fatigue during cycling. If the leg musculature becomes fatigued during hybrid cycling, voluntary arm activity takes over the entire propulsion and the legs will only move passively together with the arms. Since there were no power measurement systems available to separately measure the power output contributions of the legs, it remained unclear to what extent the legs contributed to the total power output (measured with the ergotrainer) during hybrid cycling. The effects of hybrid cycling might have been larger if strong lower-limb muscle contractions (i.e. large power output of the legs) were ensured over the entire exercise session and during the whole training program. For this purpose, first a conditioning phase for the paralyzed legs (e.g. FES-induced leg cycling or resistance training of the quadriceps muscles[6]) for the people in the hybrid cycle group should have been performed.

Clinical implications

Based on the current thesis and the existing literature,[53,118] it can be stated that staying physically active is essential to prevent deconditioning in people with long-term SCI. In chapters 4, 5 and 7 it was demonstrated that both the hybrid cycle and handcycle are effective exercise modalities to improve aspects of fitness, physical activity and health in this vulnerable population. This finding was supported by several other studies on the effects of hybrid cycling[23,73,147,148] and handcycling[152,153] in people with SCI. The hypothesis that hybrid cycling would induce larger beneficial effects than handcycling alone due to the larger active muscle mass was not supported in this thesis; except for an increase in lean mass of the legs, there were no notable benefits of the added FES-induced leg exercise, promoting handcycling as a cheaper and more accessible exercise mode for improving fitness, physical activity and health in people with long-term SCI. However, in chapter 3 it was demonstrated that hybrid cycling induces higher metabolic and cardiorespiratory responses at equal subjective exercise intensity levels than handcycling, suggesting that hybrid cycling is more suitable for fighting obesity and increasing cardiorespiratory fitness in people with long-term SCI. Moreover, the addition of FES-induced leg exercise to arm exercise alone has been shown to provide supplementary benefits on vascular[147,148] and musculoskeletal systems[11,29,141] in the lower extremities. Considering these potential greater benefits of hybrid exercise over arm exercise alone, people with SCI should implement hybrid exercise (e.g. cycling or rowing) next to their other physical activities (e.g. wheelchair propulsion or handcycling) in daily life.

However, in the Netherlands, hybrid exercise modalities are not yet commonly used in clinical rehabilitation and SCI aftercare. Many rehabilitation professionals and people with SCI are not completely familiar with the potential greater benefits of hybrid exercise over upper-body exercise alone. In only two of the eight Dutch rehabilitation centers with a specialized SCI unit there is a hybrid cycle available, and compared to the other mobility and exercise devices available in these centers (e.g. the handcycle), this cycle is not used very often. An important practical reason for this is that hybrid cycle exercise takes relatively much time due to the placements of the electrodes and the transfers that need to be made. Moreover, since the purchase of a hybrid cycle is relatively expensive, not everybody is in the position to acquire such a cycle, making it difficult for people with SCI to maintain hybrid exercise for the long term.

Therefore, alternative methods for hybrid exercise should be considered. As previously stated in this thesis, FES-induced leg exercise in people with SCI is essential to prevent lower-body deterioration, and should be introduced early during clinical rehabilitation and maintained throughout the lifespan of these people. However, it might be more convenient and feasible to use this technique separately from the conventional upper-body activities (e.g. handcycling). For example, a relatively easy and cheap way to reactivate the paralyzed lower-limb musculature, is to use a custom-made FES shorts (Axiobionics, Ann Arbor, MI, USA), containing embedded surface electrodes with build-in leads that can be connected to a portable stimulator (NeuroPro, Axiobionics, Ann Arbor, MI, USA).[142] These FES shorts can be worn under normal pants and the electrodes are automatically aligned over the gluteal and hamstring muscles when putting them on.

To conclude, clinical rehabilitation should focus on the prevention of deconditioning in people with SCI, and offer a model of lifetime follow-up rehabilitation in this population. In this context, FES-induced leg exercise (either hybrid exercise or leg exercise alone) plays a crucial role.

Main conclusions

- The metabolic and cardiorespiratory response during hybrid cycling are higher than during handcycling when exercising at equal subjective exercise intensity levels.
- Both the 16-week hybrid cycle and handcycle exercise intervention led to positive effects on aspects of fitness, physical activity and health.
- Except for lean mass of the legs, there were no notable additional benefits of the hybrid cycle intervention over the handcycle intervention.

- In future studies on the effects of hybrid exercise, first a conditioning phase of the paralyzed lower limbs should be performed.
- Specific graded exercise testing should be used to properly set objective training intensity.
- To be able to include a sufficient number of participants and to prevent a high drop-out rate and non-compliance, future research should consider how to make exercise interventions more feasible and attractive for people with long-term SCI.
- FES-induced leg exercise should be introduced early during clinical rehabilitation and should be maintained throughout the lifespan of people with SCI.
- Clinical rehabilitation should focus on the prevention of deconditioning in people with SCI.
- Clinical rehabilitation should offer a model of lifetime follow-up rehabilitation for people with SCI.